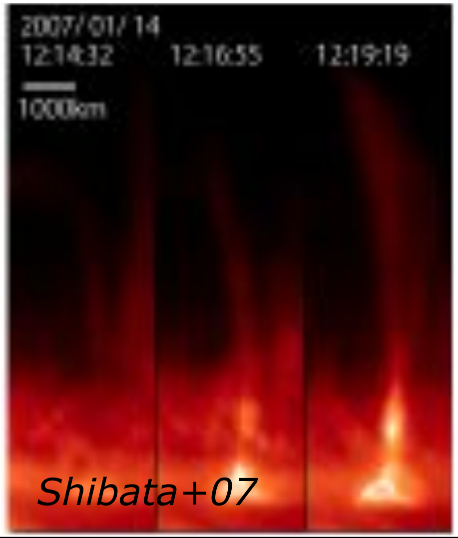
CLASP (Re-flight planning) ~aiming at establishing the magnetic field diagnostic technique by the UV spectro-polarimetry~

Ishikawa Ryoko, Masahito Kubo, Narukage Noriyuki, Ryohei Kano, Hirohisa Hara, Kazuya Shinoda, SuematsuYoshiho, Okamoto Taketen, Toshihiro Tsuzuki (National Astronomical Observatory of Japan), Shinnosuke Ishikawa (Space Science Laboratory), Masaki Yoshida (Graduate University for Advanced Studies), D. McKenzie, K. Kobayashi, L. Rachmeler (NASA / MSFC), F. Auchere (IAS), J. Trujillo Bueno (IAC), CLASP1 & 2 team

Hinode discoveries and remaining issue

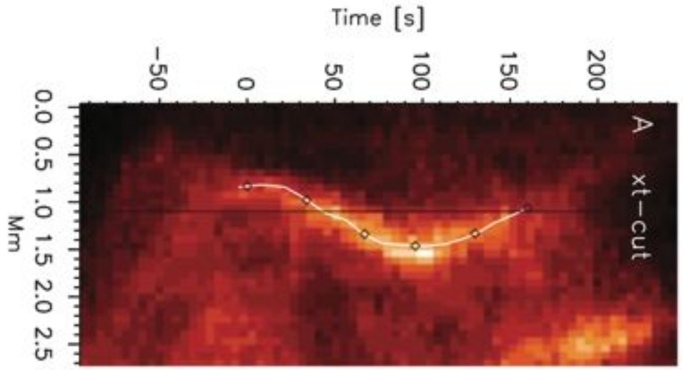
Chromosphere
Imaging
$\beta<1$

Ubiquitous jets



Shibata+07

lack of magnetic field info. in chromosphere ~corona



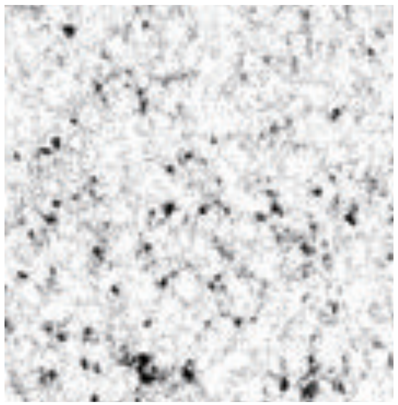
De Pontieu+07

MHD waves

Okamoto+07

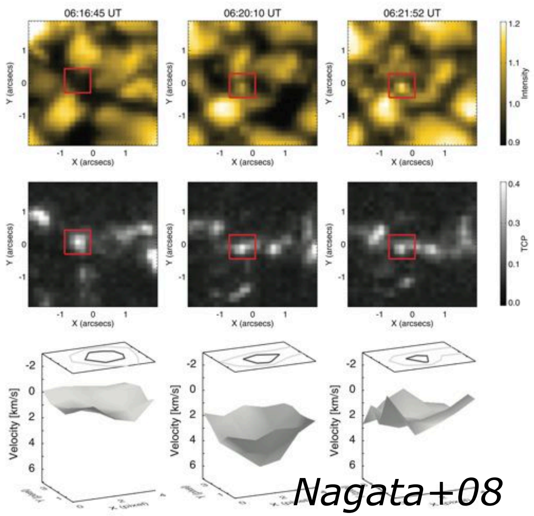
Photosphere
Spectro-Polarimetry
$\beta \geqq 1$

Ubiquitous loops (hG)



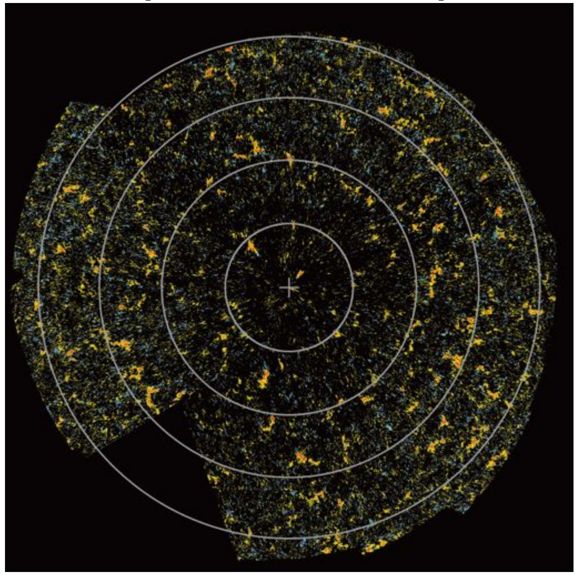
Ishikawa+08, Lites+08

Formation of super-equipartition (kG) field



Nagata+08

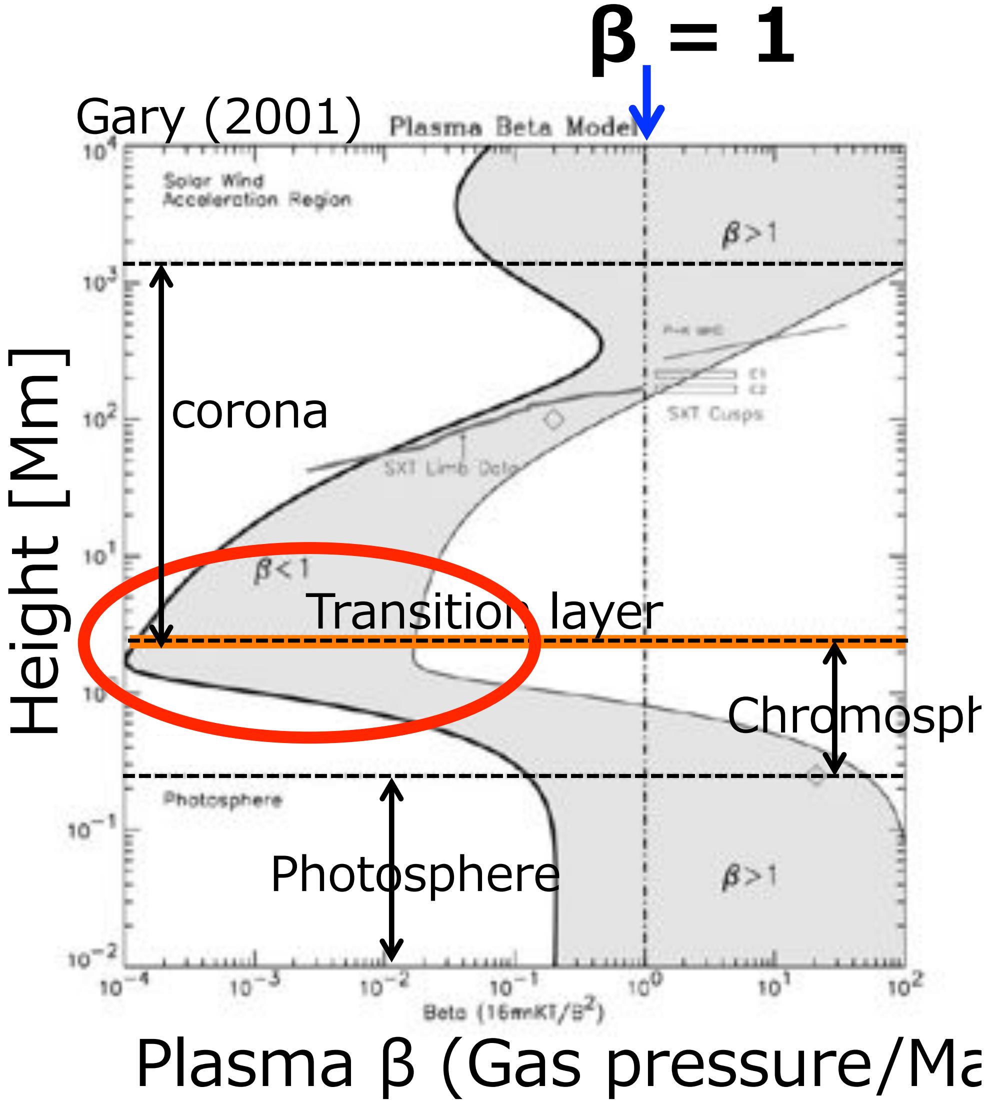
kG patches in pole



Tsuneta+08, Shinota+12

The purpose of CLASP series

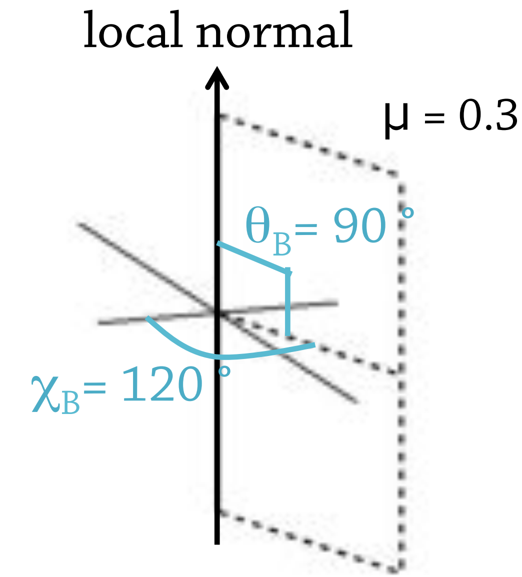
- β<1 upper chromosphere ~Establishment of magnetic field diagnostic technique of the transition region
  - Spectro-polarimetry in the UV range
  - Derivation of the magnetic field information using the Hanle effect



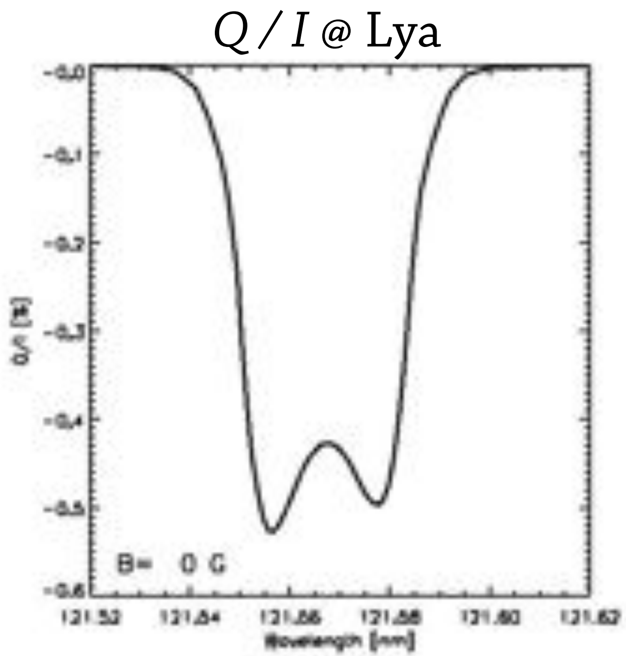
Hanle effect

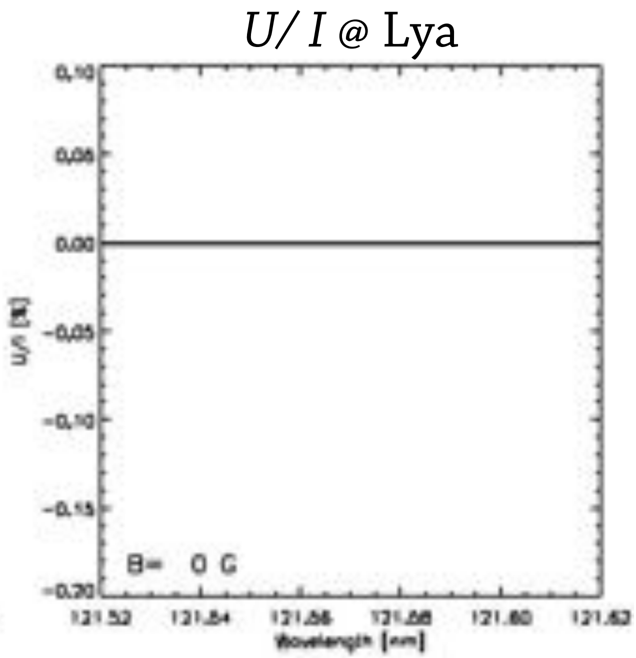
- The effect of the magnetic field modifies scattering polarization caused by the anisotropic radiation field

  → **Deriving a magnetic field vector** from **the degree of modulation**



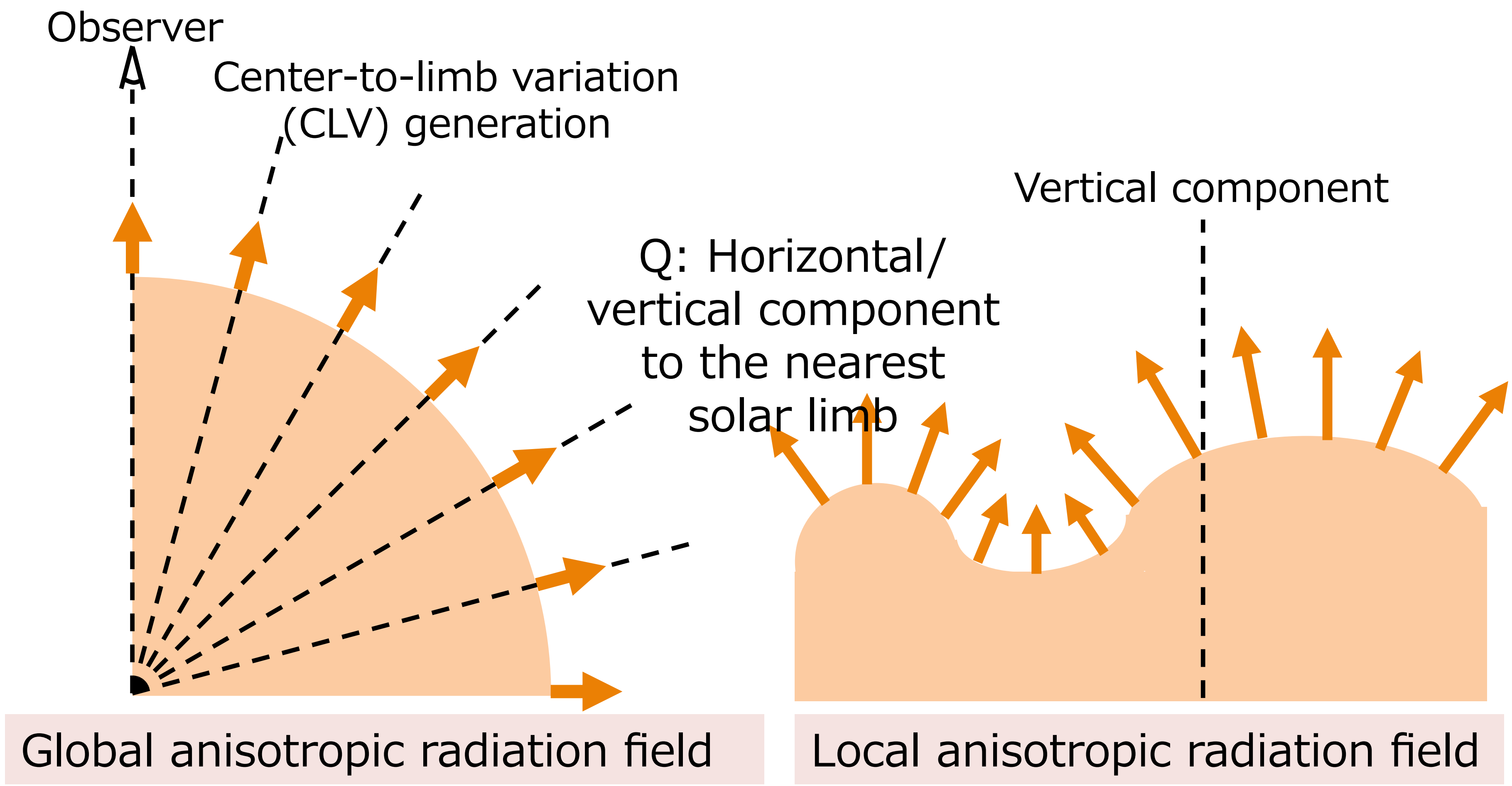
+Q:Horizontal to the nearest solar limb





Difficulty of interpretation

- In addition to the atmosphere stratification, local anisotropic radiation field contributes to the modulation of scattered polarization

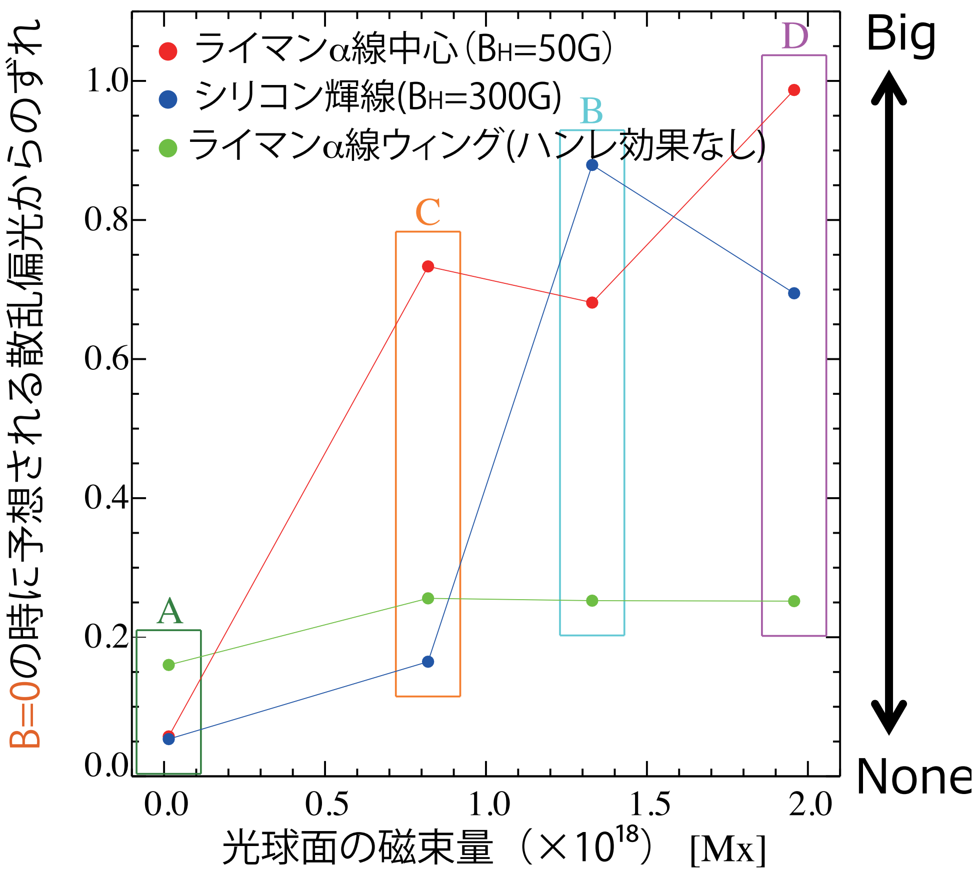


Strategy taken in CLASP1

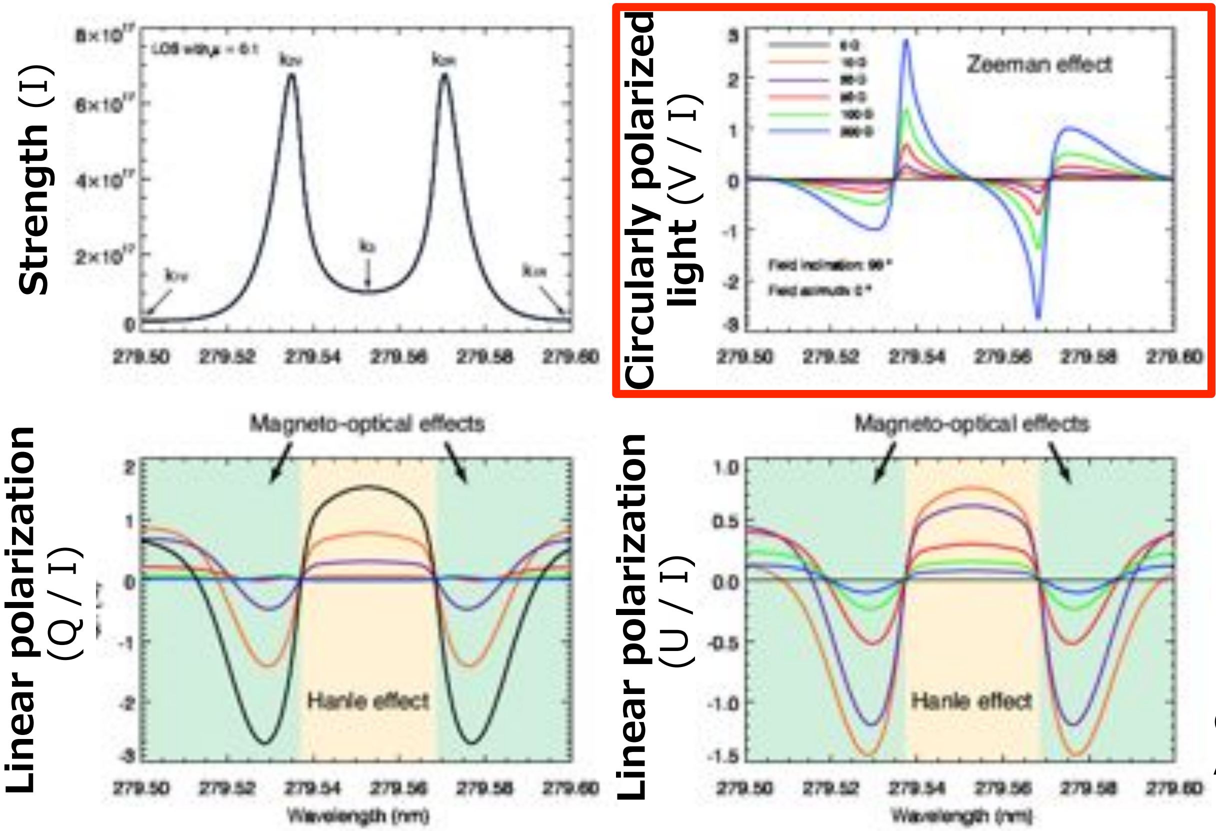
- Comparing the behavior of the polarization of the different spectral lines of sensitivity to Hanle effect
- Photospheric magnetic field (By HMI) as the collateral evidence of the presence or absence of Hanle effect

Hanle effect was detected!

Ishikawa et al. Submitted



CLASP2: MgII h & k Observation



$B_H = 25$ G

$B_{LOS} = 50G \sim 0.3\%$ (spectrally convolved)

MgII h & k line When Lya Formation of altitude difference:~150km

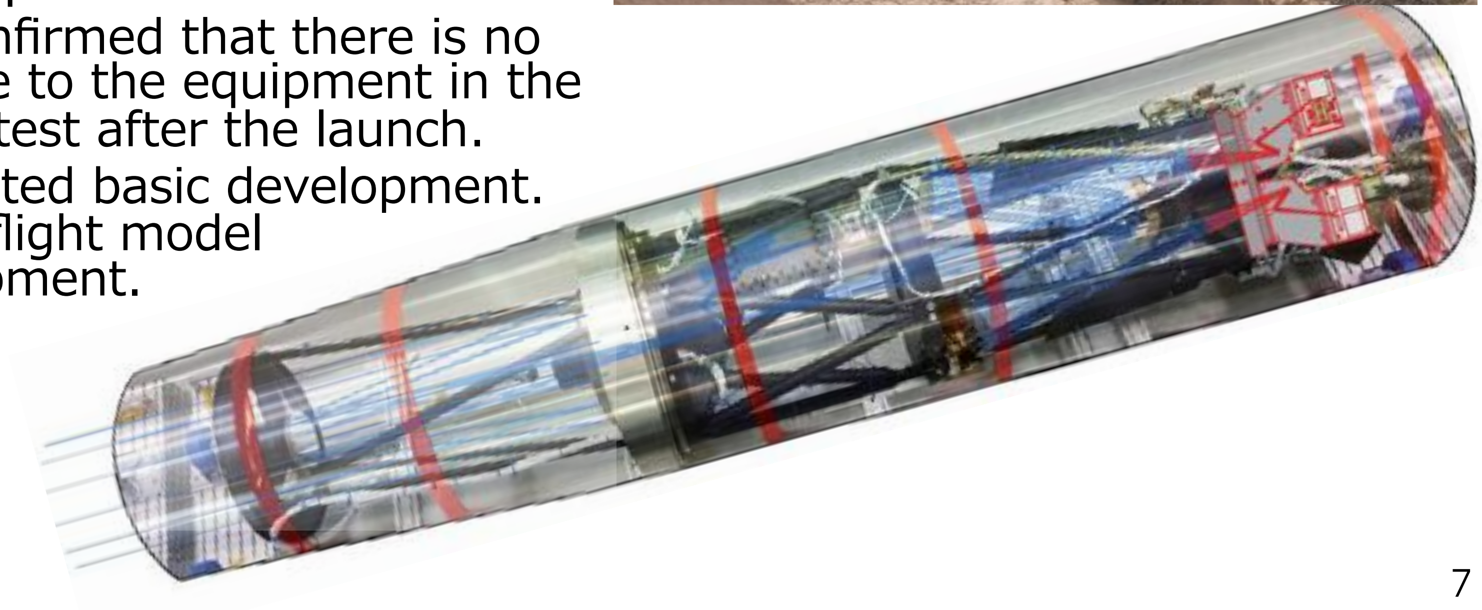
del Pino Aleman et al. (2016)
Alaina Ballester et al. (2016)

- By measuring the circularly polarization from the Zeeman effect, we can obtain direct evidence of Hanle effect and aims to derive a vector field.

For UV multiple wavelength (Lya, Si III, Mg II h & k line) Spectro-Polarimetry!

Chromospheric LAyer Spectro-Polarimeter Two (CLASP2)

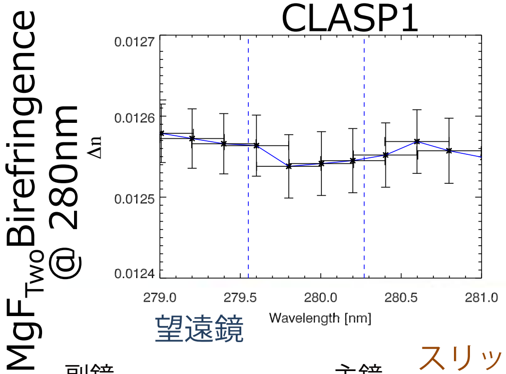
- December 2016, NASA adopted the full-scale start!
- Minimum optical and structural change, MgII h & k line polarization spectroscopic observations by implementing.
- By the end of 2017 March, the observation instrument comes back to Japan. Refurbishment
  - It is confirmed that there is no damage to the equipment in the optical test after the launch.
  - Completed basic development. To the flight model development.



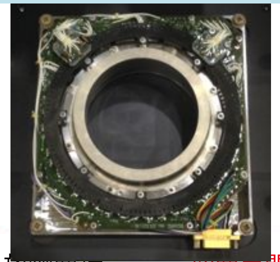
Developmental status

Wave plate

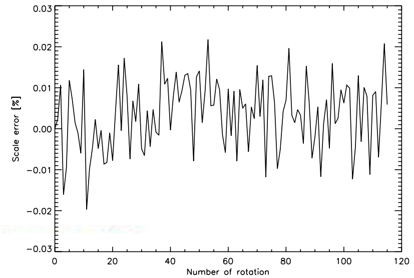
Continue to use the flight-wave plate of CLASP1

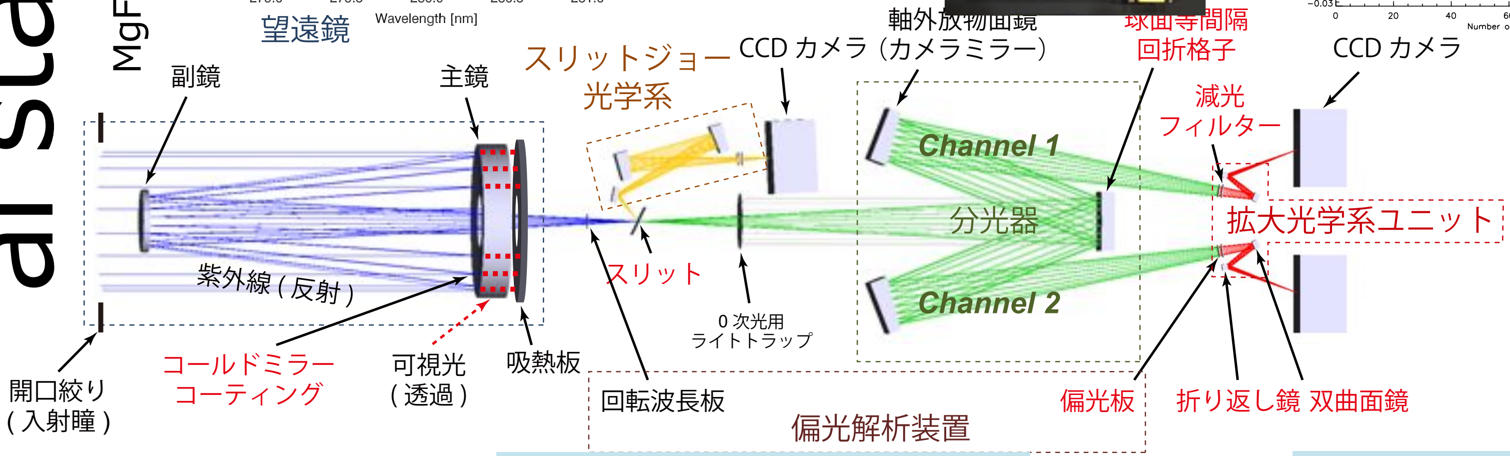


Polarization modulation unit

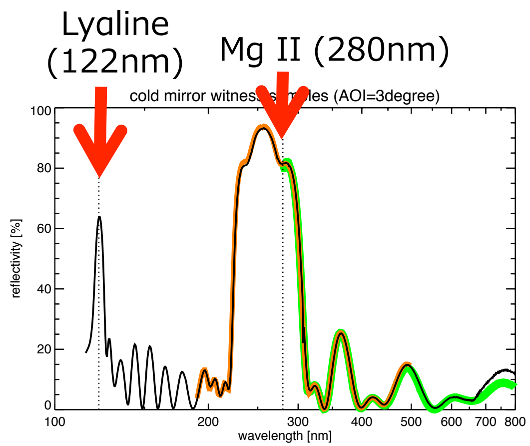


Rotation speed improvements completed to use for CLASP2





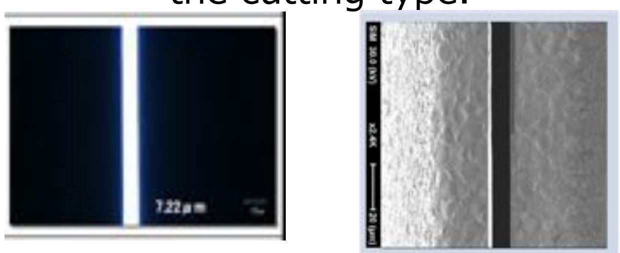
Cold mirror coating



Reflectometry measured @UVSOR

slit (7um width)

Prototype both of the transmission type and cutting type. Decision to the cutting type.

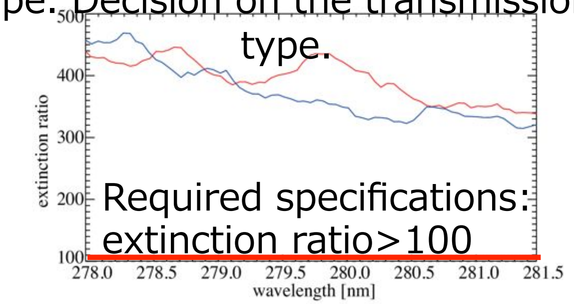


Transmission type Cutting type

Observation by the microscope photo

Polarizer

Prototype complete both of the transmission type and reflection type. Decision on the transmission type.



wavelength vs. Measurement results of the extinction ratio

CLASP2 Summary of plan

Re-flying is planning in 2019 spring!

	CLASP1	CLASP2
Observables	Stokes-I, Q, U	Stokes-I, Q, U, V
wavelength	Lya (122 nm) & Si III (121 nm)	Mg II h & k at 280 nm
resolution	0.01 nm (wavelength), 2-3″ (space)	0.01 nm (wavelength), 1-2″ (space)
FOV of the spectrometer (Slit length)	400 "	200 "
Observation target	Quiet region (Heliocentric & limb)	Quiet region (Heliocentric & limb) & Plage

Observation target and its purpose

- Quiet region@Heliocentric: data acquisition for the polarization calibration
- Quiet region@near the limb: derive the CLV of the scatterring polarization (to be compared with CLASP1)
- Plage:Observe Stokes-I, Q, U, V to derive the magnetic field of the upper chromosphere using the Hanle & Zeeman effect

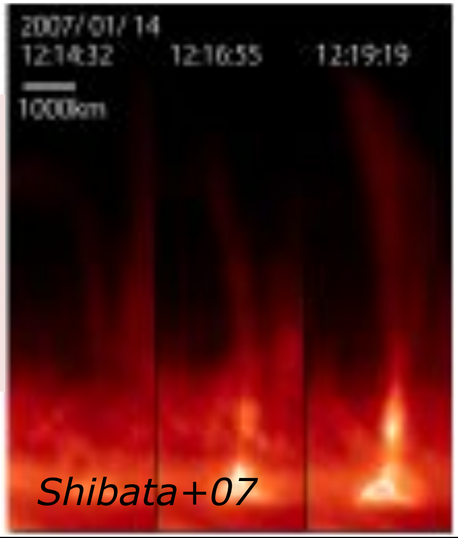
CLASP再飛翔計画
～紫外線偏光観測による磁場診断手法確立を目指して～

石川遼子, 久保雅仁, 成影典之, 鹿野良平, 原弘久, 篠田一也, 末松芳法, 岡本丈典, 都築俊宏 (国立天文台), 石川真之介 (宇宙科学研究所), 吉田正樹 (総合研究大学院大学), D. McKenzie, K. Kobayashi, L. Rachmeler (NASA/MSFC), F. Auchere (IAS), J. Trujillo Bueno (IAC), CLASP1 & 2 team

ひのでによる発見と残された課題

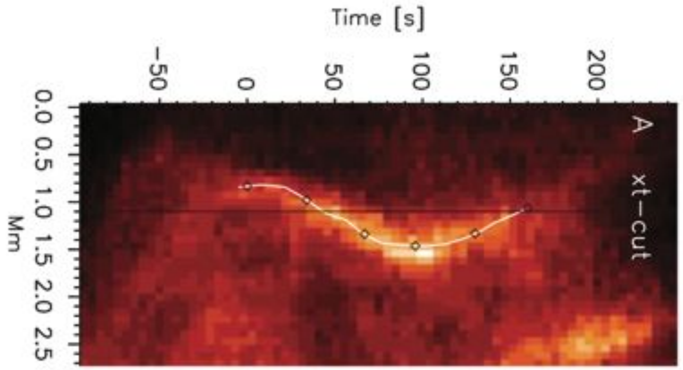
彩層
撮像観測
β<1

ユビキタスジェット



Shibata+07

彩層〜コロナの
磁場情報の欠如



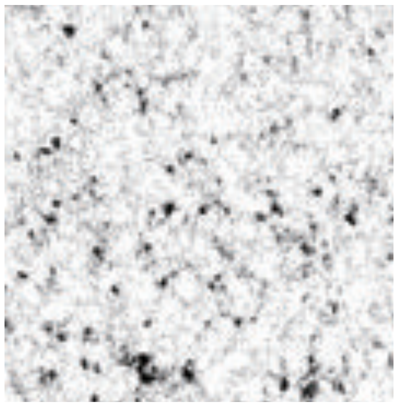
De Pontieu+07

MHD波動

Okamoto+07

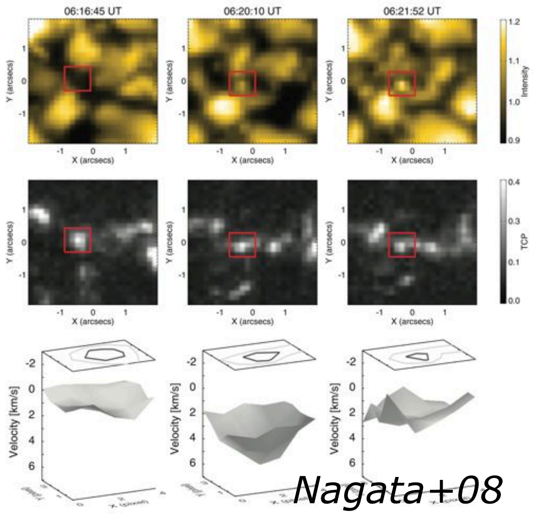
光球
偏光分光観測
β≧1

粒状斑サイズのユビキタスループ(hG)



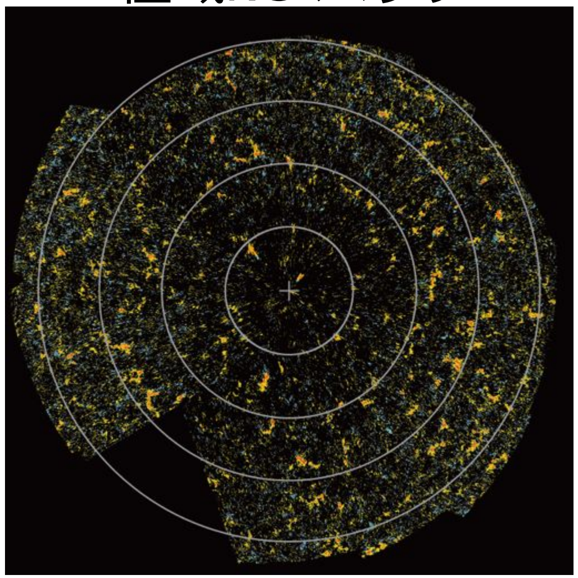
Ishikawa+08, Lites+08

超エクイパーティション磁場(kG)の形成



Nagata+08

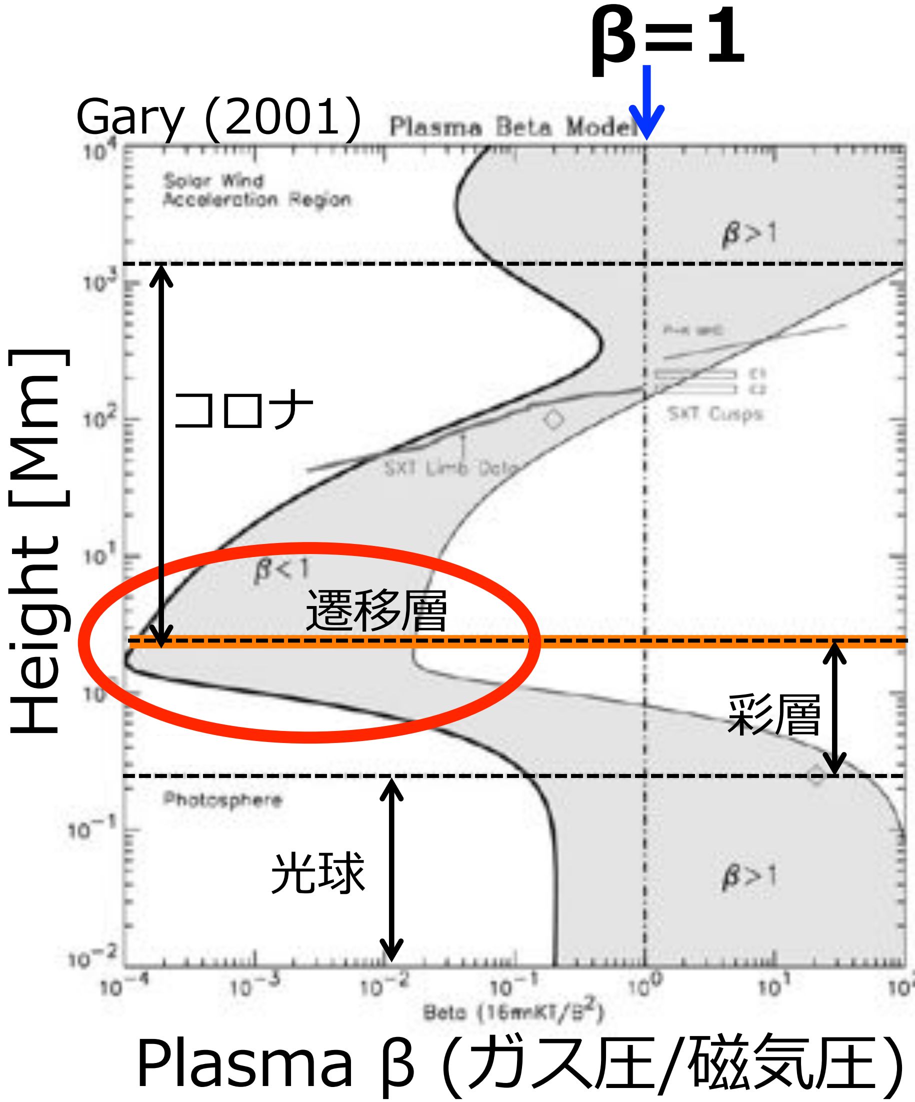
極域kG パッチ



Tsuneta+08, Shinota+12

CLASPシリーズの目的

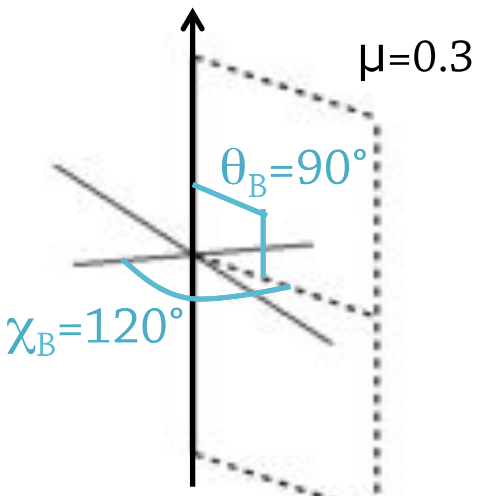
- β<1となる彩層上部～遷移層の磁場診断手法の確立
  - 紫外線領域での偏光分光観測
  - ハンレ効果を用いた磁場情報の導出



ハンレ効果

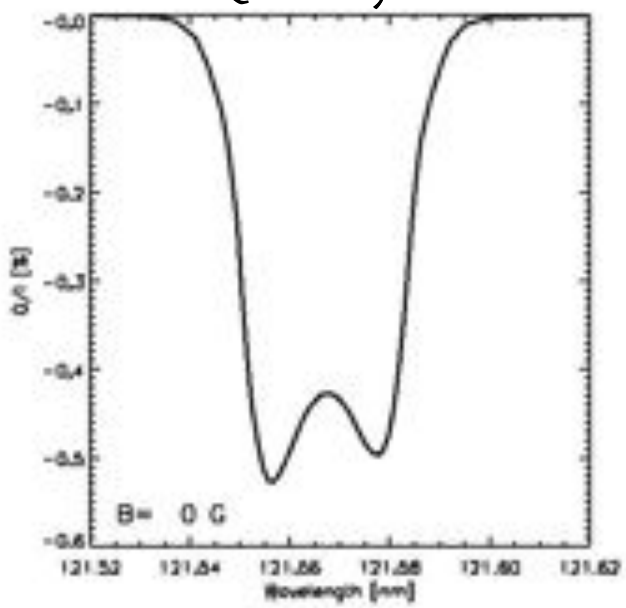
- 非等方な輻射場によって生じた散乱偏光を磁場が変調する効果

→**変調の度合い**から**磁場ベクトルを導出**

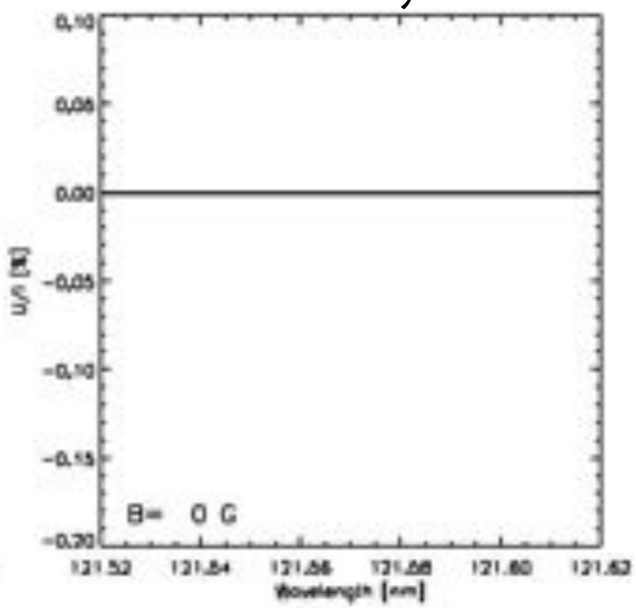


+Q:太陽の縁に平行

Q/I @ Lya

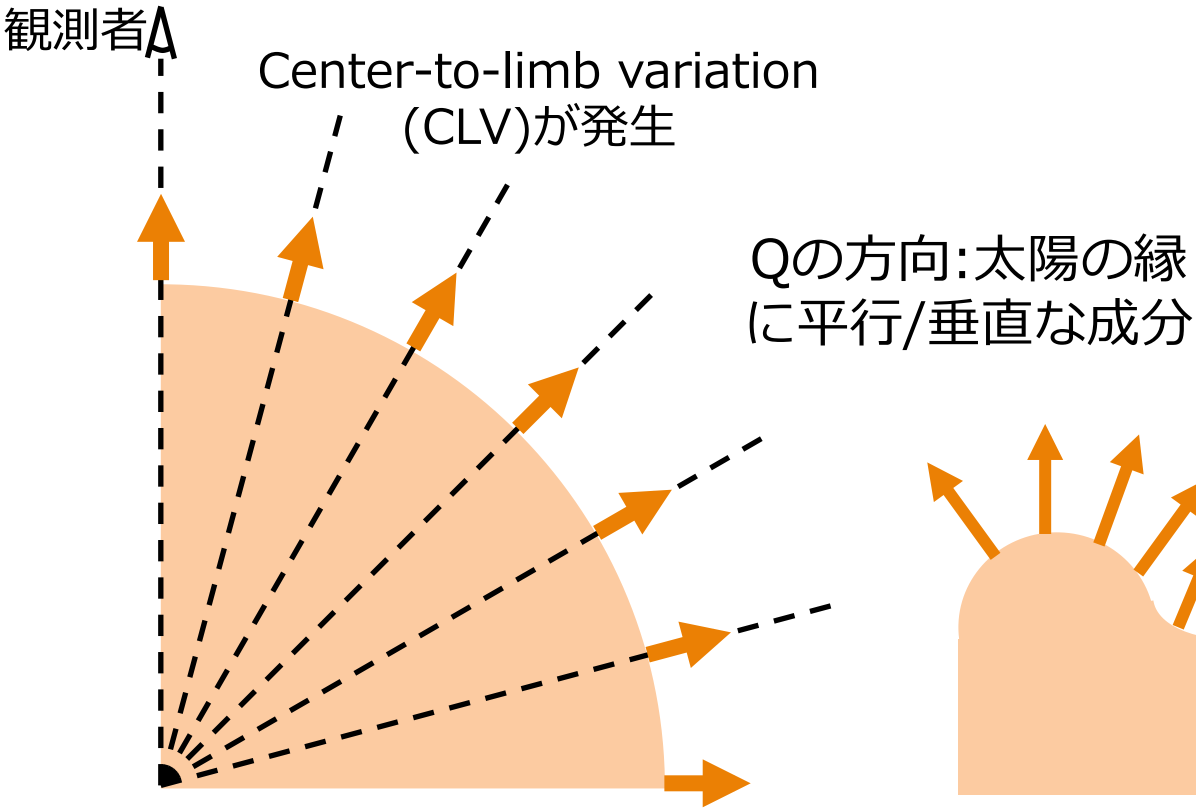


U/I @ Lya

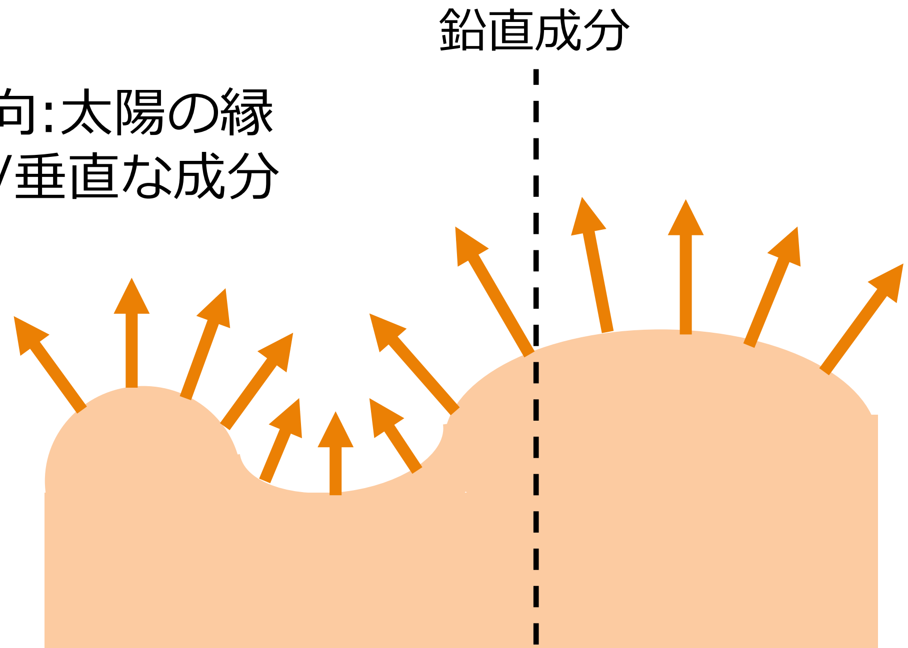


解釈の難しさ

- 大気成層に加えて、局所的な輻射場の非等方性も散乱偏光の変調に寄与



大局的な輻射場の非等方性



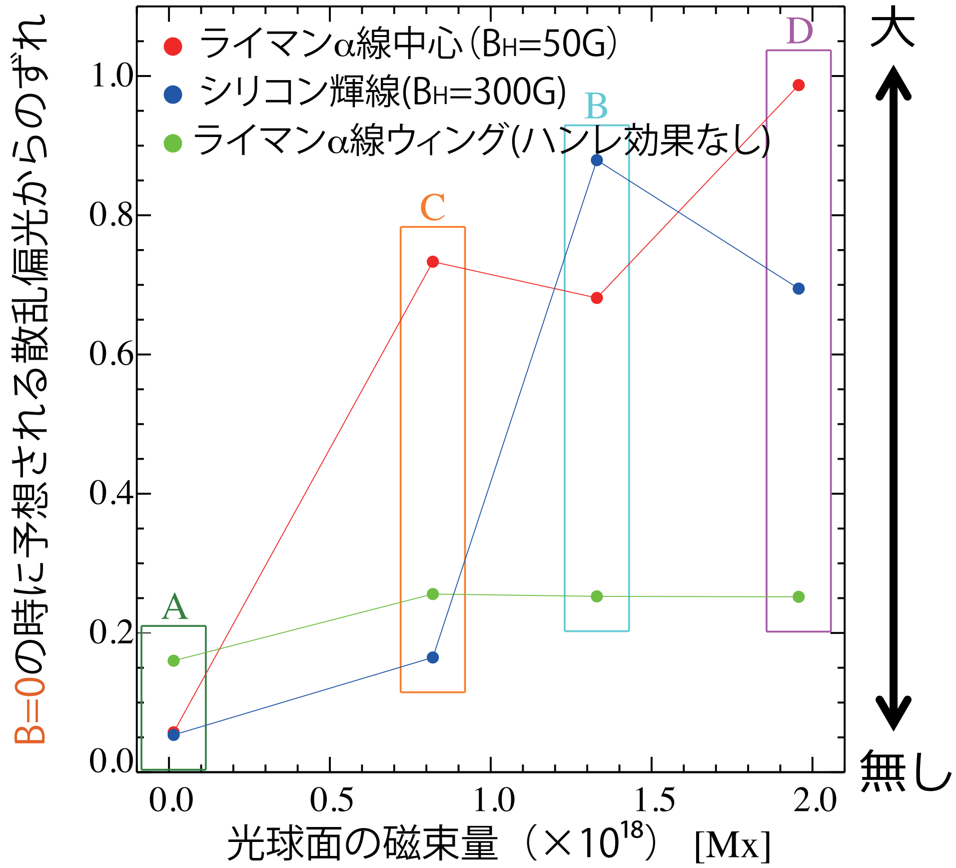
局所的な輻射場の非等方性

CLASP1でとった戦略

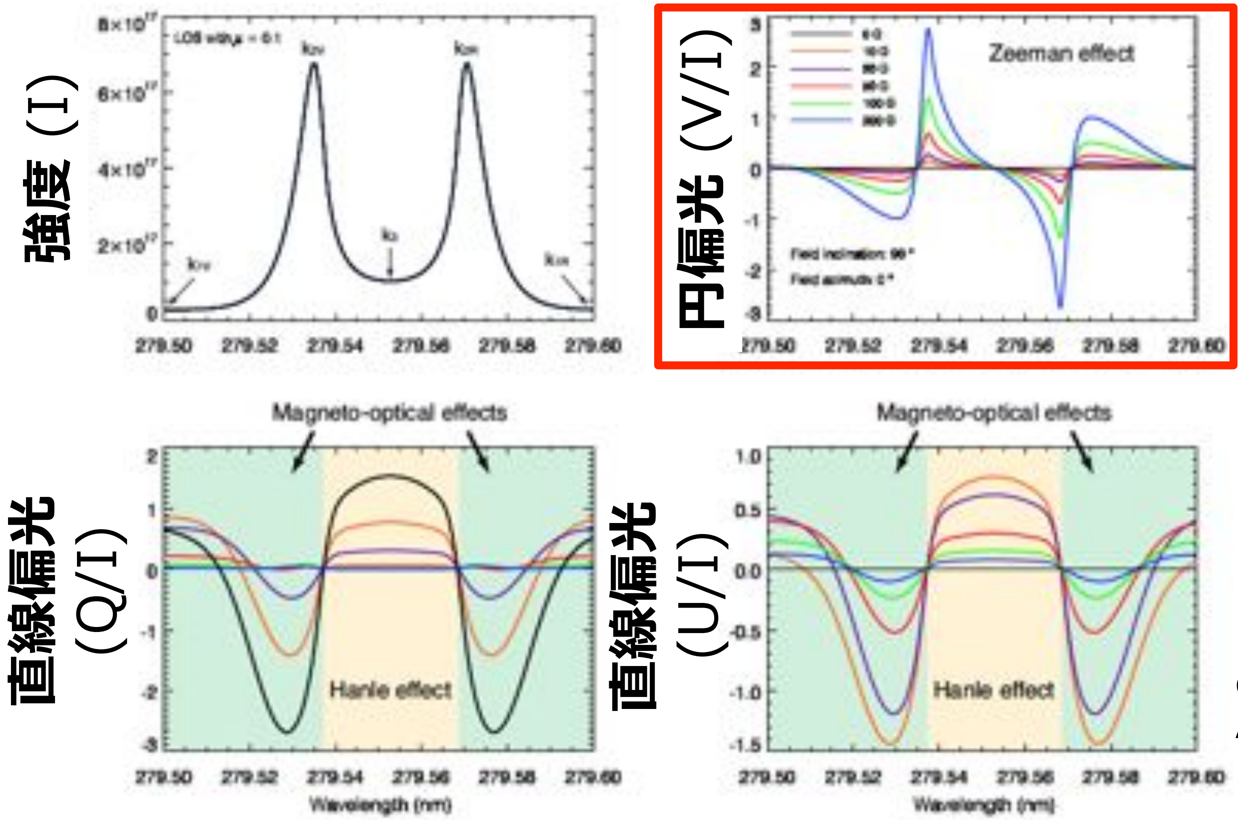
- ハンレ効果に対する感度の異なるスペクトル線の偏光の振る舞いを比較
- 光球磁場（By HMI）をハンレ効果の有無の傍証とする

ハンレ効果の検出はできた！

Ishikawa et al. submitted



CLASP2: MgII h & k 線の観測



B_H=25 G

B_{LOS}=50G ~ 0.3 %
(spectrally convolved)

MgII h & k線とLyaの形成高度差：～150km

del Pino Aleman et al. (2016)
Alaina Ballester et al. (2016)

- ゼーマン効果由来の円偏光を測定することで、ハンレ効果の直接的証拠を得、ベクトル磁場の導出を目指す。

UV多波長 (Lya, Si III, Mg II h&k線) 偏光分光観測へ

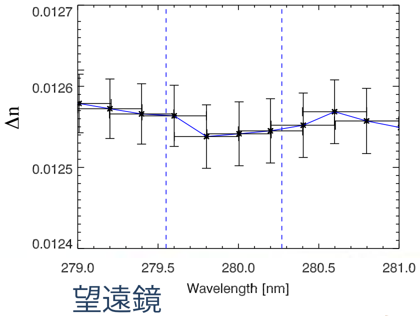
Chromospheric LAyer Spectro-Polarimeter 2 (CLASP2)

- 2016年12月NASAに採択され本格始動!
- 最小の光学・構造変更を施しMgII h & k線の偏光分光観測を実施.
- 2017年3月末, 日本に観測装置が帰還. 改修へ
  - 打ち上げ後の光学試験で装置に損傷がないことは確認済み.
  - 基礎開発は完了. フライト品開発へ.

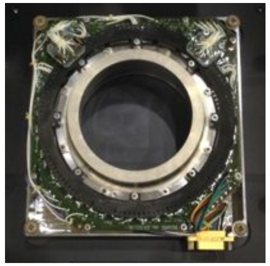
開発状況

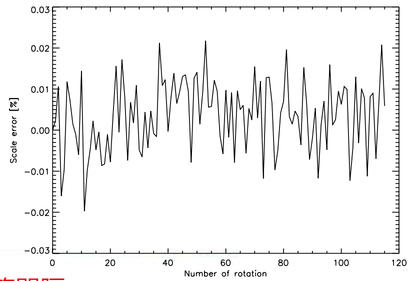
波長板
CLASP1フライト
波長板を継続利用

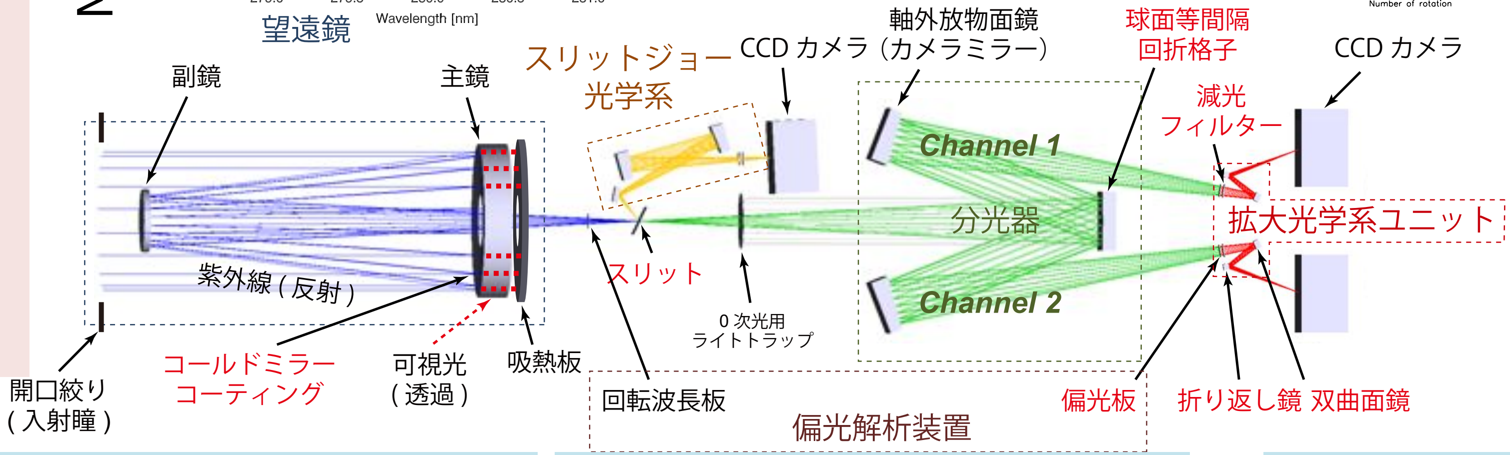
MgF_2複屈折率
@280nm



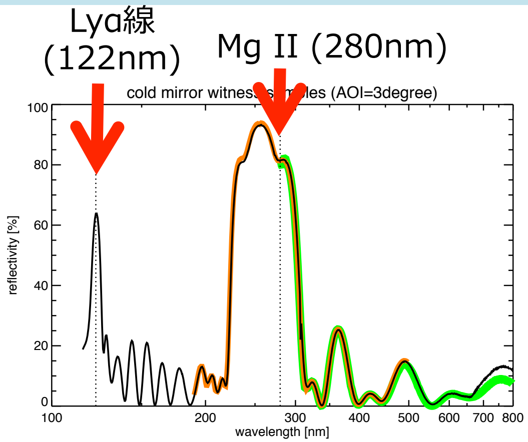
偏光変調ユニット
CLASP2用に回転
速度改良完了







コールドミラーコート



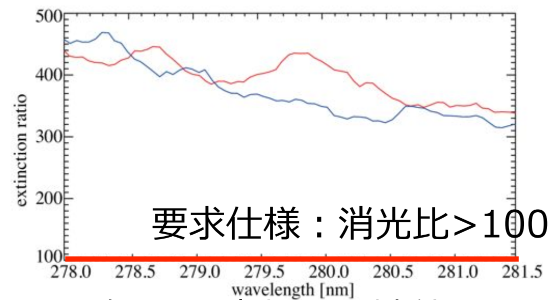
反射率測定@UVSOR結果

スリット (7um幅)
透過型と切削型の両方を
試作。切削型に決定。

透過型　切削型

顕微鏡による観察写真

偏光板
透過型・反射型の両方を
試作完了。透過型に決定。



波長 vs. 消光比の測定結果

CLASP2計画のまとめ

2019年春の再飛翔を計画中！

	CLASP1	CLASP2
観測量	Stokes-I, Q, U	Stokes-I, Q, U, V
波長	Lya (122 nm) & Si III (121 nm)	Mg II h & k at 280 nm
分解能	0.01 nm (波長), 2-3” (空間)	0.01 nm (波長), 1-2” (空間)
分光器の視野 (スリット長)	400”	200”
観測ターゲット	静穏領域 (太陽中心 & 縁)	静穏領域 (太陽中心 & 縁) & プラージュ

観測ターゲットとその目的

- 静穏領域@太陽中心：偏光較正用データ取得
- 静穏領域@縁近傍：散乱偏光のCLV取得(CLASP1との比較)
- プラージュ：Stokes-I, Q, U, Vを取得し、ハンレ＆ゼーマン効果を使って彩層上部の磁場を導出